Pre-Tropical Cyclone Squall Lines and the Connection to the Diurnal Cycle during Hurricane Laura (2020)

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Motivation

Convective features unlike TC rain bands have been increasingly been observed in landfalling tropical cyclones in recent years. This squall line produced by Hurricane Laura (2020) generated several tornado and severe thunderstorm warnings in south Louisiana. Investigating the behavior, characteristics, and possible causes of these pre-TC squall lines will help better prepare forecasters in the future and aid in the understanding of TC and the TC diurnal cycle as a whole.

Background

Previous foundational studies such as Meng & Zhang, 2012; Parker & Johnson, 2000; and Bluestein & Jain, 1985 have characterized midlatitude squall lines as well as pre-TC squall lines in the Pacific Ocean Basin. These studies were used to model this investigation as well as provide quantitative criteria for this case study.

Research Questions

1. Do diurnal pulses have similar characteristics as midlatitude squall lines?
2. Are these "squall lines" behaving more like TC rain bands or midlatitude squall lines?
3. What are the environmental characteristics surrounding this feature?
4. Is the TC Diurnal Cycle a factor in generating this line of convection?
5. How is the HRRR forecast model handling the squall line?

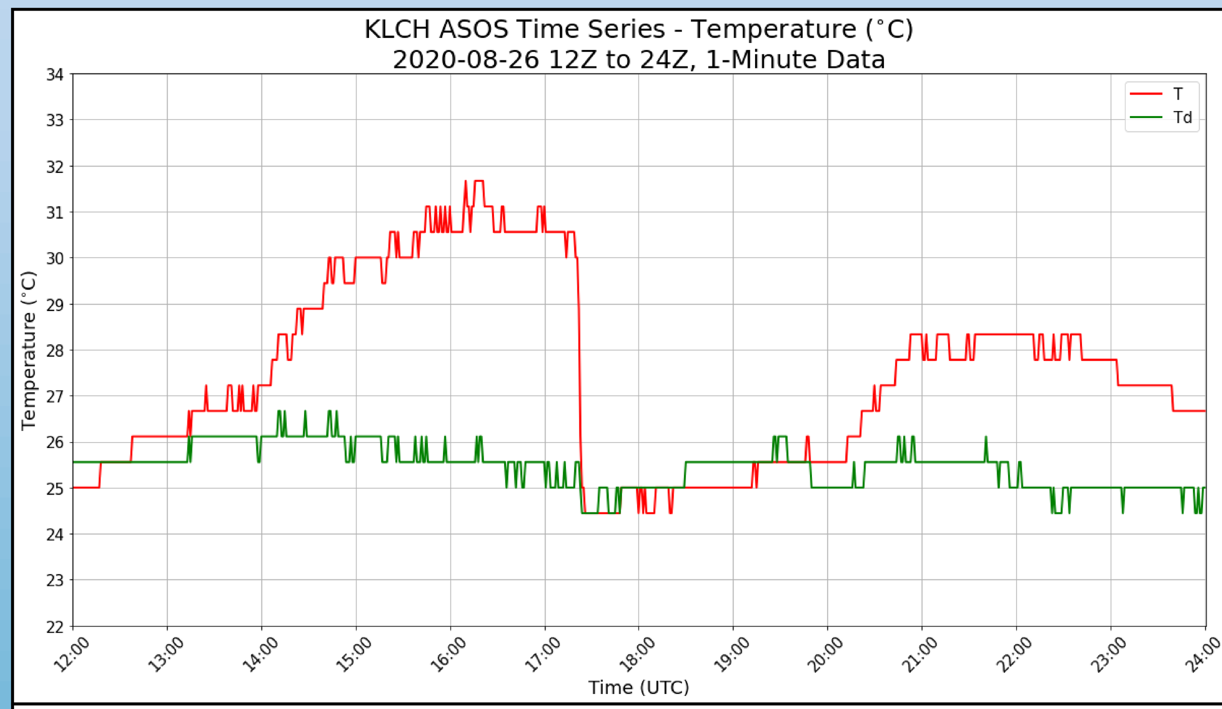
Data - see QR code link slide 2

- Surface Data—ASOS, Buoys, RAWS, UAH MIPS
- NEXRAD Radar Data
- KLCH sounding
- 915 MHz wind profiler from UAH deployment
- HRRR forecast model archive data

Criteria	From Past Literature	Laura Observations
Formation Mode	BL, BB, BA, EA	Broken Line
Organizational Mode	TS, LS, PS	Trailing Stratiform
Propagation Speed (m/s)	12.5 m/s on average, R = 200-350km: 5-10 m/s R = 350-500km: 13.89 m/s	Avg. 6.00 m/s for R = 234-342 km Avg. 6.48 m/s for R = 350-412km
Length (km)	Min: 50 km long, less than 50km wide Max: 220 km	Max: >100 km
Lifetime/Lifespan	3-4 hours	< 3 hours at full extent
Distance from Center	20 dBZ region must be clearly separated from the main body of the TC	Satisfied
Diurnal Clock Timing	See Figure in Diurnal Cycle Discussion	See Figure on Slide 3
Reflectivity	35 dBZ band in which 40 dBZ band is embedded is strictly continuous Max reflectivity: 57-62 dBZ	Satisfied

Squall Line Classification Results

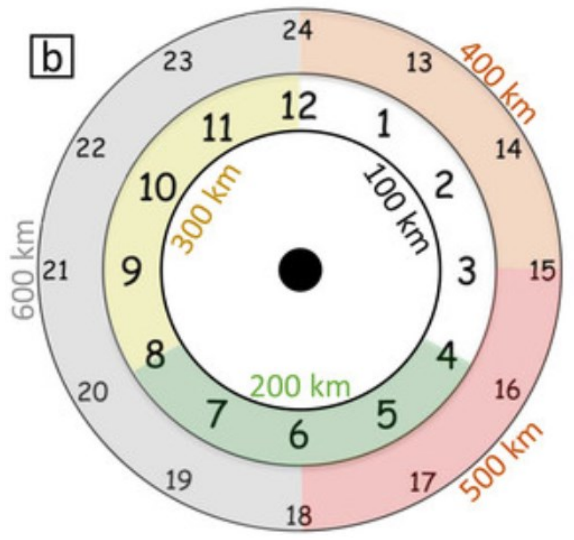
As seen in the table above, Laura's squall line does fall within the criteria from past literature. Slides 7 and 8 give a more detailed look at the pre-TC squall line environment and the wind shear analysis. The temperature plot to the right also demonstrates the strength of the cold pool observed at Lake Charles.

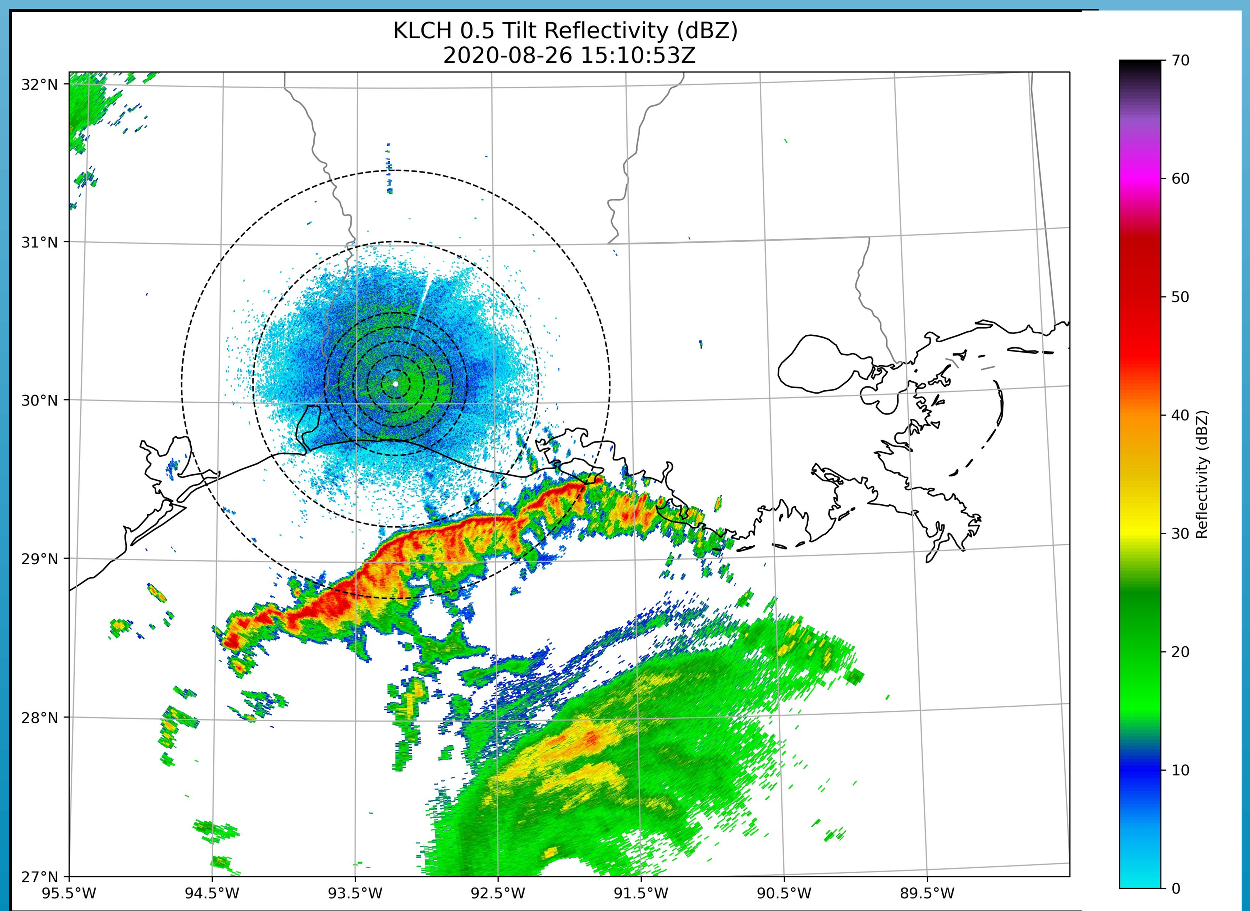


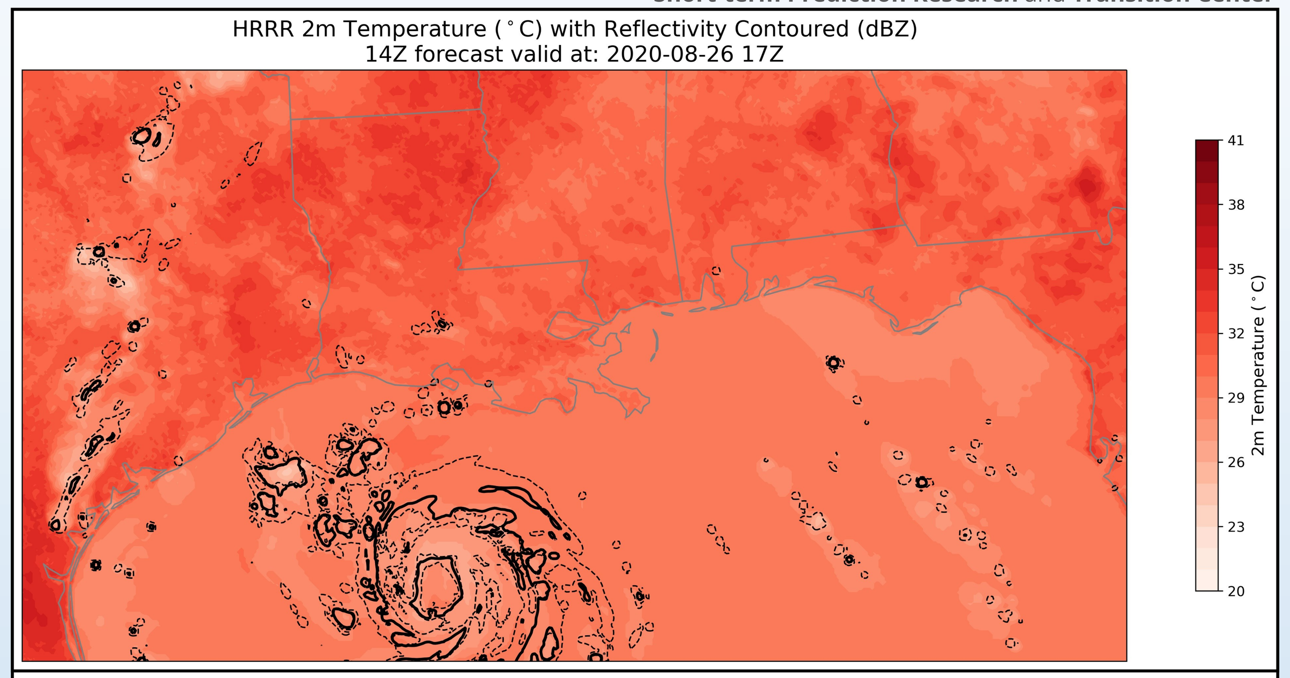
Temperature drop at 1722Z: 4.5 °C

Diurnal Cycle Discussion

Based on the expanded diurnal clock from Ditchek et al. 2019a (below), distances were measured for Laura's squall line at key times during its lifespan and were classified in order to determine if they lined up with this clock. The results can be found in the QR code link (slide 4). There were enough times that lined up with the clock to define this squall line feature as a diurnal pulse as defined by previous studies.







HRRR Model Analysis

- 2m Temperature and Composite Reflectivity Analyzed for both analysis and forecast times (see slide 5)
- Compared to observed radar data, model did not resolve the feature well (despite being a CAM) even though these features show similarities to midlatitude squall lines
- Little evidence of cold pool over land in model output
- In runs where a linear squall line-like feature was observed, timing was off by 5-6 hours for where it would have been located
- Point forecasts also failed to show cold pool as seen in observations (slide 6)
- It would not be recommended to use this model alone to forecast these features operationally.

Future Work:

This work will be carried over to two other case studies of Isaias (2020) and Ida (2021) for my master's thesis.

I will apply the same criteria and methods to these cases in order to try to understand these types of features in a more general sense.

Acknowledgements:

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